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## References

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## Measurement of the Exclusive Reaction

$$\nu_e + {}^{12}\text{C} \rightarrow e + {}^{12}\text{N}(g.s.)$$

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### Abstract

We have measured the cross-section for the exclusive reaction,  ${}^{12}\text{C}(\nu_e, e){}^{12}\text{N}(g.s.)$ . The experiment was performed with a 15-ton fine-grained tracking detector exposed to  $\nu_e$ 's with equivalent energy of 37 MeV. The detector was triggered by single electrons and the exclusive inverse-beta reaction identified by the delayed coincidence of the  ${}^{12}\text{N}(g.s.)$  positron-decay. The flux-averaged cross-section was measured to be  $1.18 \pm 0.11(stat) \pm 0.13(sys) \times 10^{-41}\text{cm}^2$ . This result is compared to recent calculations.

Neutrino-induced nuclear reactions play an important role in nuclear and particle physics and in astrophysics. Measurement of specific nuclear transitions could be used to elucidate the spin-isospin structure of the nuclear weak currents. It is also of interest for supernova and solar neutrino detectors, and for precision  $\nu e$  experiments. Yet, to date no experimental cross-sections were available for neutrino-nucleus interactions to well defined ("two body") final states.

We report the first measurement of the reaction  ${}^{12}\text{C}(\nu_e, e){}^{12}\text{N}(g.s.)$ , with  $\nu_e$  from a beam stop neutrino source. The  $\nu_e$  spectrum is given by the Michel spectrum, with a maximum energy of 52.8 MeV. The reaction was identified by the delayed coincidence of the  ${}^{12}\text{N}(g.s.)$  decay following a trigger on the prompt electron. The 17.34 MeV Q-value for the  $\nu_e + {}^{12}\text{C} \rightarrow e + {}^{12}\text{N}$  transition limited the prompt electron to have less than 35 MeV kinetic energy. The subsequent  $\beta$  decay, with meanlife  $\tau = 15.9$  ms and endpoint energy  $E_\beta = 16.4$  MeV, uniquely identified the reaction to the nitrogen ground-state as all of the excited states of  ${}^{12}\text{N}$  undergo strong decay.

The experiment was performed at the Clinton P. Anderson Meson Physics Facility (FAMPE) of the Los Alamos National Laboratory. The central detector has a total mass of 15 metric tons, 85% of which are  $\text{C}^{12}$ , provided  $6.40 \pm 0.13 \times 10^{26}$   ${}^{12}\text{C}$  target nuclei. It was arranged in a sandwich structure with forty layers. Each layer

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consists of a plane of plastic scintillator and a flash-chamber module. There are two passive shields and a MWPC system to reduce the cosmic-ray background, and a shield of 630 cm thick steel to reduce beam-associated neutrons.<sup>1</sup> Data were collected between October 1983 and December 1986 with  $1.10 \pm 10^{23}$  protons on the beam stop, corresponding to  $(8.3 \pm 0.7) \times 10^{14} \mu\text{m}^2$  at the geometric mean distance of 893 cm.<sup>2</sup>

The detector was triggered by a coincidence of three consecutive scintillation layers with energy deposition between 1 and 16 MeV per scintillator, with no veto from the MWPC system. Triggers were collected during the beam spill (Beam-On), and for a longer period between spills (Beam-Off) to monitor cosmic-ray backgrounds. Various cuts were imposed on the data to select the prompt electrons, including a requirement of  $dE/dx > 10$  MeV/inch and the visible energy less than 24 MeV. For delayed coincident activity, scintillation contours at the either end of the prompt trigger were searched. Energy deposits between 4.5 MeV and 12.0 MeV during the time  $48\mu\text{s} < t < 64\text{ms}$  following the trigger were required. Thus, 304 candidates in the Beam-On data set and 124 in Beam-Off data set were identified. Their time spectra were shown in the Figure. Assuming they contain contributions from the exponential decay of  $^{12}\text{N}(g.s.)$  and from a uniformly distributed background, a maximum likelihood fit was performed.  $187 \pm 17$   $^{12}\text{N}(12.6) \rightarrow e^- + ^{12}\text{N}(g.s.)$  events were assigned in the Beam-On data. For the Beam-Off data it was found to be  $17 \pm 21$ , consistent with no signal.

A detailed Monte Carlo simulation of the detector response was performed to determine the detection efficiency. The overall detection efficiency is  $3.0 \pm 0.2\%$ . Therefore, the flux weighted cross section was determined to be  $(1.18 \pm 0.11(stat) \pm 0.13(sys)) \times 10^{-41} \text{cm}^2$ . This reaction has been studied by several authors. Donnelly<sup>3</sup> calculated this cross section to be  $0.94 \times 10^{-41} \text{cm}^2$ .<sup>3</sup>

## References

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